

Investigation of bedload transport off Karwar coast, southwest coast of India

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Radiotracer experiments were carried out in two phases to study the movement of bedload near Anjadeep island off Karwar coast to select a suitable dumping site for disposal of dredged spoil. ^{46}Sc as powdered scandium glass was used as radiotracer. From hydraulic considerations two sites were selected. Study showed that the materials dumped at about 2 km Northwest from the tip of Anjadeep island used to transport towards the proposed approach channel. Average velocity of transport was about 4.4 meters per day and the mean transport rate of the order of 31 kg per day per metre width of the bed. Materials dumped at 4 km Northwest would move offshore, away from the proposed channel and harbour area. In this location the general velocity of transport was found to be 0.6 meters per day and sediment transport rate of the order of 30 kg per day per metre width of the bed.

Improper choice of dumping site for dredged material results in the sediment transport back into the navigational channel and huge expenses are involved in the subsequent dredging operations. Dumping site is selected from hydraulic considerations, mathematical modelling and studies on physical scale down model. Transport of sediment on seabed at a particular depth is governed by the effect of waves and underwater currents and relatively easy to detect by tracer technique over a period of four to five months. Radioactive isotopes as tracers are widely used to study the dynamic behaviour of bedload sediment.

The present study refers to the selection of dumping site for a proposed harbour in northern Karnataka off Karwar coast near Anjadeep island. From the hydraulic considerations two dumping sites were suggested by Central Water & Power Research Station, Pune. Suitability of both the sites was studied using radiotracer technique.

Karwar is located on the western coast in northern Karnataka (Fig. 1). The background survey covering an area of about 10 km^2 before the injection of radiotracer during the each experiment, was carried out to get the natural radiation level on the seabed. Waterproof scintillation detector mounted on an iron sled and connected to a scaler/ratemeter was used for the survey. Position of the detector was fixed by available positioning system. Average background was found to be of the order of 1000 - 1500 counts per minute (cpm) in both the areas.

Radiotracer should have identical physico-chemical properties and hydrodynamic behaviour as of natural sediment. The radiotracer ^{46}Sc in the form of 1% scandium glass having the specific gravity and the particle size distribution ($75\mu\text{-}2000\mu$) similar to that of natural sediment was prepared. Amount of tracer used was 300 g and the activity was about 8 Ci (296 GBq) during both the injections.

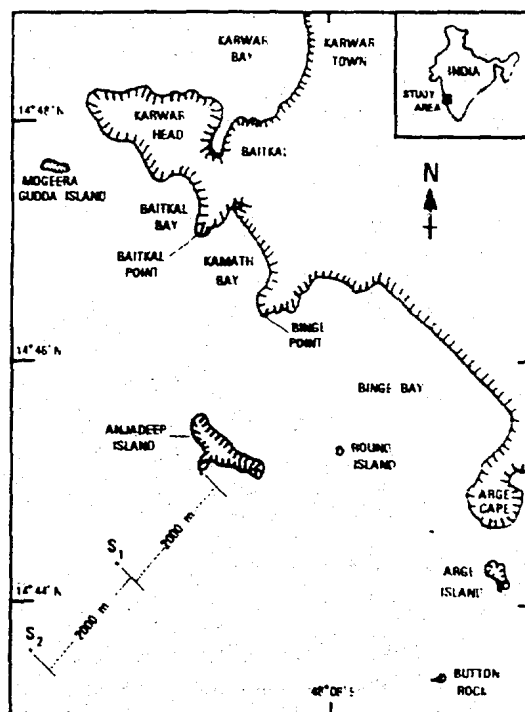


Fig. 1—Site plan of the location of experiment

For each experiment radiotracer was mixed with about 5 kg sand obtained from the site, inside a specially designed remote operated injection apparatus. Radiotracer was released on to seabed at location S1 in the year 1990 during the first experiment and at location S2 in the year 1991 during the second experiment. Each experiment was followed by about three post injection trackings. First one was immediately after the injection and remaining two with the gap of about one month, each generally conducted during the fair weather condition. The trackings were carried out with the same detector sled as was used for background survey. All the data points were plotted on the location map.

Qualitative Treatment—All the data were corrected for background radiation and decay of the radiotracer. Isocount contour maps prepared using data obtained from three post injection trackings for the two experiments are shown in Figs 2, 3. Following observations are made from these maps.

Experiment at S1—From Fig. 2 it may be seen that during the first experiment the tracer has tendency to spread uniformly around the injection point immediately after the injection. A part of lighter fraction of the material, however, had a tendency to move eastwards. Between May and August, the material moved parallel to the coast up to the eastern tip of the Anjadweep island and then abruptly towards the coast. The rate of sediment movement accelerated after August due to higher wave action. The patch got widened thereafter indicating that the material has a tendency to spread

out evenly in all directions at the end of southwest monsoon season. A south westerly movement was also observed possibly due to the return drift during the month of October.

Studies clearly show that the material dumped at this site prior to southwest monsoon would move towards the proposed channel during the monsoon and would have tendency to silt up the channel. Results showed that the material has a tendency to move eastwards and then northwards. Hence the dumping ground located further offshore of Anjadweep island in the north direction was studied.

Experiment at S2—From Fig. 3 it may be seen that during the second experiment the material had a tendency to spread locally around the injection point. A part of the lighter fraction of the materials, however, had a tendency to move westwards.

Between May and August, the material had a tendency to move westerly away from the shoreline. Tracking results for August indicate spread of material upto 1 km towards southwest direction, though the rate is slow.

The studies clearly show that the materials dumped at this location prior to southwest monsoon would move towards the south westerly direction and offshore during the monsoon and would have a tendency to drift away from the shore which is favourable condition from the point of view of avoiding recirculation of the dredged material.

Quantitative Treatment—A general direction of movement is drawn based on the isocount contour maps (Fig. 2, 3). Cumulative product of count rate 'C' and length of the lateral spread 'x' for different

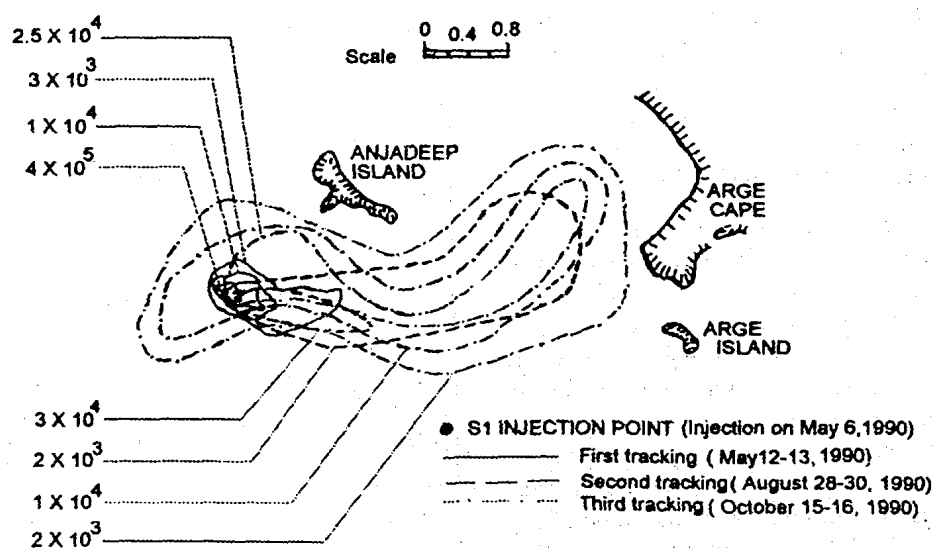


Fig. 2—Isocount contour map of radiotracer study at S₁

locations along the general axis of transport are plotted for each tracking. The curves so generated are known as 'transport diagrams'. For each diagram, location of the weighted centre of gravity along the axis of movement was found out using the following equation,

$$\bar{x} = \frac{\int C \cdot x \cdot dx}{\int C \cdot dx}$$

The transport diagrams and locations of centre of gravity are shown in Fig. 4 for dumping sites S1 and S2 respectively. Mean velocity of movement is calculated from the shifts in centre of gravity in two successive trackings. Results are summarised in Table 1 for both the locations.

During the first experiment between May and August velocity of the movement of the radiotracer was about 2.6 m per day which was less compared to the velocity of 6.3 m per day between August and October. This could be due to higher wave action after the month of August. During the second experiment general velocity of radiotracer transport was found to be about 0.6 m per day which is very

slow in comparison with that of the first experiment which could be because of bathymetry of the site.

Transport thickness—As the bedload moves, the tracer gets mixed within the moving bed. This depth of tracer burial is called 'transport thickness' and is the mean distance between the surface of the bed and most deeply buried radioactive particles. Determination of transport thickness is based on countrate balance. The total integrated countrate N ($\text{cpm} \cdot \text{m}^2$) observed during the tracking is related to the transport thickness²

$$N = \iint n \cdot ds = \frac{\beta k A}{\alpha E} (1 - e^{-\alpha E})$$

where,

$N = \iint n \cdot ds$ = the countrate integrated over the whole surface area of tracer patch, k = calibration factor of the detector used, A = total activity injected, α = attenuation coefficient; characteristic of the isotope, bed material and geometry of the detector, β = function of transport thickness and shape of the distribution of tracer concentration with

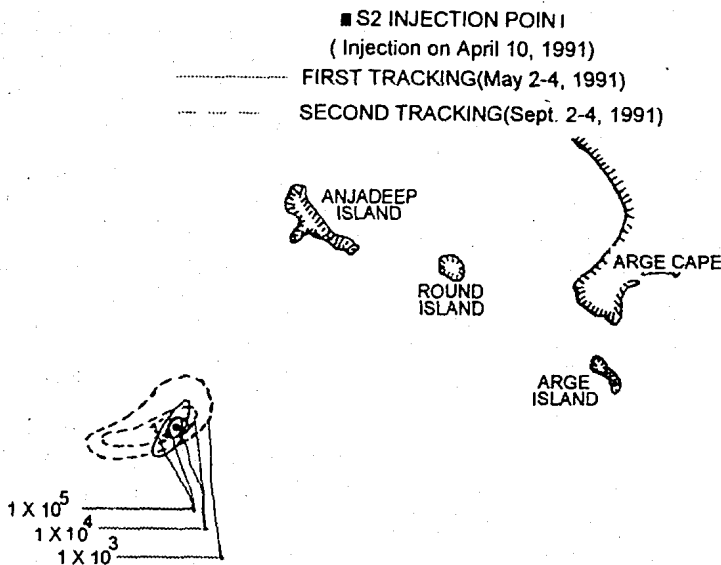


Fig. 3—Isocount contour map of radiotracer study at S₂

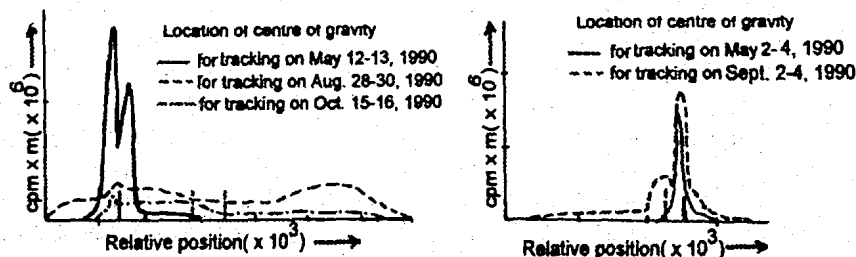


Fig. 4—Transport diagram for radiotracer study at S₁ and S₂

Table 1—Vetocity and transport rate for experiments at S₁ and S₂

Tracking no.	Days after injection	Activity spread $\times 10^{10}$ (cpm.m ²)	Velocity of movement (m/d)	Transport thickness (cm)	Transport rate per metre width (kg per day)
A Experiment at location S ₁					
1	0	3.8	-	0.8	-
2	109	3.3	2.6	1.9	60
3	157	4.3	6.3	0.1	2
B Experiment at location S ₂					
1	26	3.3	-	1.6	-
2	148	2.1	0.6	3.3	30

depth, E = transport thickness.

The transport thickness E , calculated from the above formula, is given in Table 1.

For calculations, $k = 4260 \text{ cpm}/\mu\text{Ci}/\text{m}^2$, $\alpha = 0.15 \text{ cm}^{-1}$ and $\beta = 1$.

The bedload transport rate Q (tonnes per day) can be expressed³ as

$$Q = \rho l V_m E$$

where,

ρ = sediment bulk density ($1.5 \text{ tonnes.m}^{-3}$), ℓ = width of transport (m), V_m = mean velocity of transport (m per day), E = transport thickness (m).

Table 1 summarises results of both the experiments carried out at locations S₁ and S₂. Mean transport rate observed at site S₁ between May to August was about 60 kg per day per metre width of the bed which is large compared to value of 2 kg per day observed between August to October. This may be because of turbulence created by strong waves during the active period of monsoon. At site S₂ mean transport rate observed between May to September was about 30 kg per day per metre width

of the bed.

Investigation of site S₁ for dumping the dredged material showed that the material would move towards south from the location of injection during southwest monsoon and enter the proposed approach channel and harbour area. Therefore this is not a favourable site. Studies carried out at site S₂ showed that the bed material would move southwest from the location of the injection point and away from the proposed approach channel and harbour area. Therefore this was considered to be a suitable site for dumping the dredged material.

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References

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